HODOSCOPIC SYSTEMS OF GAS-DISCHARGE COUNTERS USED IN EXPERIMENTS WITH ACCELERATORS

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(presented by V. P. Dzhelepov)

1. Hodoscopic systems of gas-discharge counters, widely used for investigation of cosmic rays, have not, in the past, been applied to experiments with accelerators. This is due to the fact that in the presence of large background radiation, the gas-discharge counter dead time leads to considerable counting losses. Such a drawback of usual hodoscopic systems is eliminated in the system proposed by Tyapkin [1], in which a short high voltage pulse is applied to the gas-discharge counters. The high voltage pulse is controlled by a limited number of fast scintillation counters selecting the events of interest. The rise of the high voltage pulse at the counters is always late with respect to the passage through the counters of the ionizing particles relating to the selected event, but the recording of them becomes possible due to the drift time of electrons. For efficient working of the counters under controlled pulse supply conditions, one should provide the conservation in the counter volume of at least one electron up to the moment of rise of the high voltage pulse. For this purpose one should apply a sufficiently low constant voltage across the counters; the smaller the diameter of the counters, the lower this voltage should be. But, on the other hand, the constant voltage must not be made too low as this would lead to a poor time resolution of the counters. An investigation [2] of the characteristics of industrially made standard counters with a cathode diameter of 20 and 30 mm, filled with a mixture of argon and isopentane, showed the possibility of obtaining under controlled pulse supply conditions efficiencies of 90-95%, the resolution time being 2×10^{-6} s. Fig. 1 shows the theoretical efficiency of 30 mm diameter counters as a function of the delay at which the high voltage pulse is applied, for minimum ionizing particles. The three curves have been calculated for constant voltages of —60, —45 and —30 V. The experimental points have been obtained at —60 and —40 V.

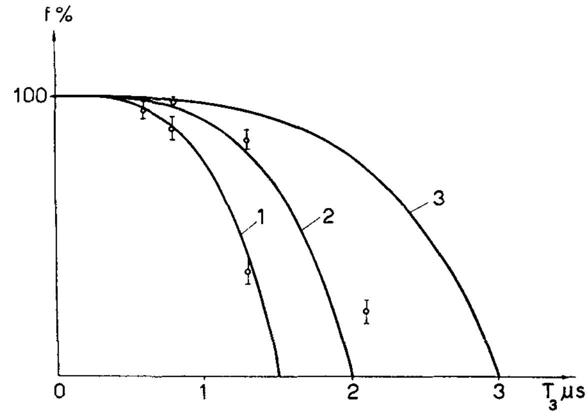

Fig. 1 Efficiency for minimum ionizing particles of 30 mm diameter counters as a function of delay of high voltage pulse.

When the high tension pulse length is about 10^{-6} s, normal operation of the counters has been observed in a wide voltage range (1500-2000 V). The triggering of a counter may be easily recorded by means of a neon lamp directly connected to the wire of the counter. This last point greatly simplifies the whole design of the system. Because of the greater simplicity and reliability of the pulsed high voltage hodoscope in comparison to ordinary hodoscopes, it is now used in a number of laboratories in the USSR also for cosmic ray work.

2. Pulsed high voltage hodoscopes were applied in a number of investigations, carried out with the synchro-cyclotron of the Joint Institute for Nuclear Research :

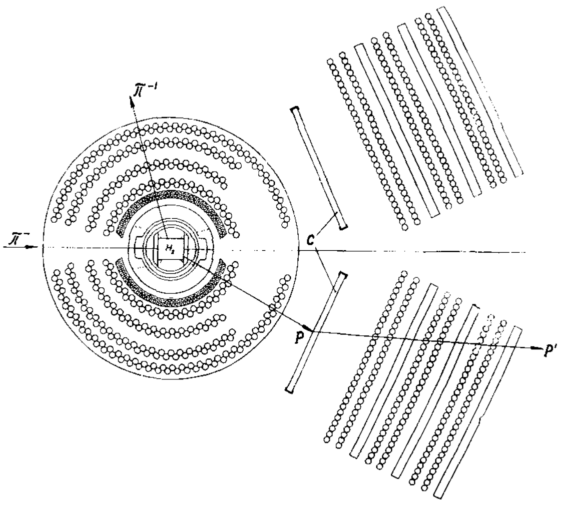

Fig. 2 Experimental set-up for investigation of the recoil proton polarization at 300 MeV π^- scattering on hydrogen.

(a) A hodoscopic system of 426 counters, placed in four concentric circles around the liquid hydrogen target [3] was used for investigation of elastic scattering of 300 MeV π^- mesons on hydrogen. The control system, consisting of scintillation counters and fast gas-discharge counters (the counters are filled with pure vapour of methylal $CH_2\,(OCH_3)_2$), selected the cases of pions scattering into the solid angle defined by the hodoscopic counters. The tracks of the scattered pion and recoil proton were indicated by neon lamps, placed on a panel with the same layout as the corresponding counters, the cases of elastic scattering being identified according to the angular correlation of the recorded tracks. The experiment was carried out with a pion beam intensity of 13 000 mesons per minute. The high efficiency of the system for recording scattered mesons allowed 1 000 cases of elastic scattering of pions on hydrogen to be obtained in 7 hours of accelerator work. The results of the experiment are described in the paper by Vasilevskij and Vishnyakov [4].

(b) For investigation of the recoil proton polarization at 300 MeV π^- meson scattering on hydrogen, two rectangular hodoscopic chambers, containing 516 counters, were added to the hodoscopic system used in experiment (a).

The scheme of the whole installation is shown in Fig. 2. On the path of the recoil protons a carbon analyzer was placed, behind which there were six rows of counters placed vertically and three rows placed horizontally. A control pulse for the hodoscope was produced for the cases in which the counters of the control system registered the scattered pion and recoil proton, emitted in the interval of angles from 15° to 40° in the laboratory co-ordinate system. When scanning the obtained photographs of the neon lamp panel, rare cases were selected in which the recoil proton scattered in the carbon analyser or in the glass walls of the counters. The results of this work are in the Proceedings of the International Conference on High Energy Physics, 1959 [5].

(c) In the determination of the correlation coefficient of proton polarization in elastic p-p scattering at an energy of 315 MeV, the control system of six scintillation counters selected the cases of interaction of both protons in the carbon analyzers. The direction of the scattered proton was determined by two rectangular hodoscopic chambers, containing 19 rows of counters. The scheme of the experiment is shown in Fig. 3. The carrying out of this experiment, involving three acts of nuclear interaction, was complicated by the reduction in beam intensity in the slowing down from 660 MeV to 315 MeV.

In scanning the photographs, the rare cases were selected where tracks of scattered protons, emerging from the carbon analyzers (see Fig. 4), were observed in both chambers. 2600 such cases were obtained for 100 hours of work with the accelerator. The results of this work are in the Proceedings of the International Conference on High Energy Physics, 1959 [6].

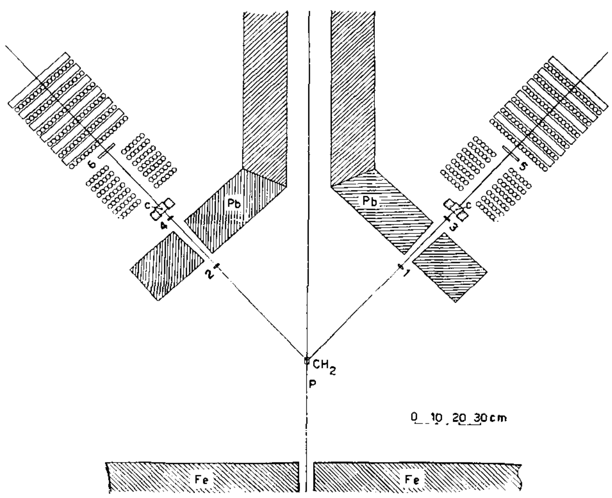

Fig. 3 Experimental set-up for studying the proton polarization correlation coefficient in p-p scattering at an energy of 315 MeV.

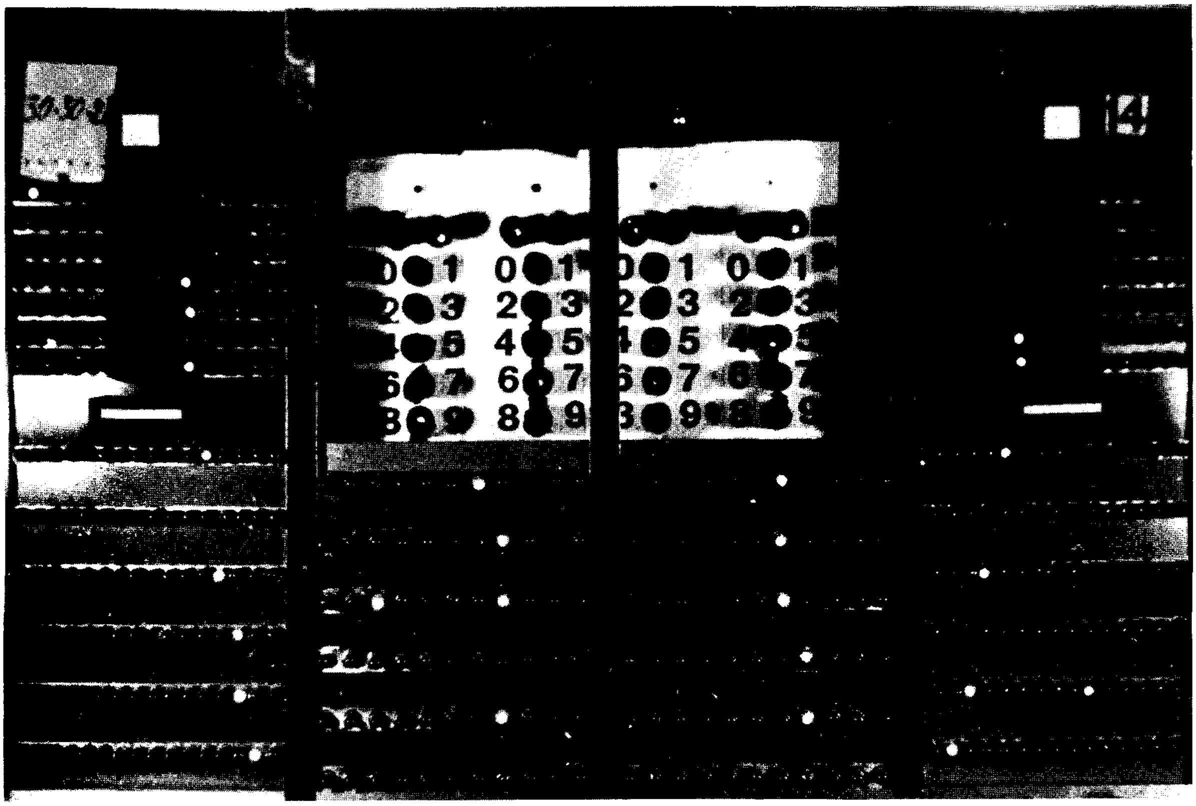

Fig. 4 The neon panel displaying the counters of Fig. 3, showing two protons scattered contemporarily in the two carbon analyzers.

As is seen from the given examples, hodoscopic systems of gas-discharge counters are not independently used in the experiments carried out with the accelerators, but are applied as a supplement to complex fast systems of scintillation counters. The control system of scintillation counters separates a class of events as narrow as possible, which contains the events the experimentalist is interested in. The hodoscopic system, helping to reliably separate these events, gives additional information on them. The additional information obtained with the hodoscope in experiment (a) was the projection on the horizontal plane of the emission angles of the scattered pion and recoil proton. In experiment (b) additional information obtained with the hodoscope made it possible to study a qualitatively more complicated phenomenon, in which two acts of nuclear interaction took place.

3. In all the experiments described above, gas-discharge counters with a diameter of 20 and 30 mm were used. For more accurate space resolution, counters of a smaller diameter are desirable. However, in consequence of untimely removing of electrons by the rising voltage, the counters with a small cathode diameter (< 10 mm) have low efficiency under controlled pulse supply conditions. The investigations we have carried out showed that counters filled with neon with the contaminant of argon (Penning type mixture) are free of this drawback.

Neon metastable atoms, produced at comparatively low voltage and then ionizing argon atoms, provide high efficiency in the regime of controlled pulse supply for counters with cathode diameter of 3-5 mm. Especially good counting characteristics were obtained for glass counters with external cathode.

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DISCUSSION

HYAMS : What is the dead time of this apparatus, I mean if it has been triggered once, how long does it take before you can trigger it again?

DZHELEPOV : It depends on the length of the high voltage pulse which is 1 μs and on the drift time of the electrons which is also 1 μs, since only electron pulses are used. The dead time of the system was thus set by the time of photography ($\sim 1/2$ s) and the neon flash lamps. The de-ionization time of the latter was $\sim 10^{-2}$ s.

FARLEY : I think there may be some confusion with the Conversi type counters that actually light up when a pulse is applied. As I understand it, these are just proportional counters which are turned on and there is no particular reason why they should have a dead time, which for proportional counters can of course be very small. Am I right in supposing that these counters do not actually light up, that no ionization is created by the pulse?

DZHELEPOV : The duration of the pulse applied to the counter is short enough, so that it would not start by itself into the discharge.